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ZONAL DIVERSITY AND COMMUNITY STRUCTURE OF INVERTEBRATE MACROFAUNA IN ROCKY INTERTIDAL AREA OF MANORA, KARACHI, PAKISTAN

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ABSTRACT: Rocky shores are important ecosystems that supports the wide variety of plants and animals and are characterized by the zonation of species. This three months study was conducted in order to recognize the community structure and zonal distribution of macro fauna at the Manora rocky shore. The sampling was done monthly for three months in the year 2014 at three tidal zones, i.e. High tide zone, Mid tide zone and Low tide zone and a zonal comparison of fauna was performed to identify the distribution pattern of species during pre-monsoon season. A total 1318 individuals belonged to 68 species were identified and counted. The phylum Mollusca was the most diverse phylum which represented by 43 species, followed by Arthropods (16 species), Echinoderms (4 species), Annelids (2 species), Cnidarians (2 species) and Porifera (1 species). The highest faunal diversity (H'= 1.429) was observed at the low tide zone, but the diversity of molluscs was high (H'=1. 329) at the mid tide zone.

KEYWORDS: Intertidal area, diversity, rocky shore, crustacea, mollusca.

INTRODUCTION

The intertidal zone is the traditional zone between the terrestrial and marine environments as some time it is exposed to the atmosphere and sometimes covered by the sea water. The rocky intertidal zone is one of the copious and heterogeneous marine environments that support variable collections of sessile and mobile organisms. About hundreds of species representing most phyla are found on rocky surfaces (Webber and Thurman, 1984; Rahman and Barkati, 2012). The organisms that live in the intertidal zone frequently need to deal with changing environmental extremes. These biological communities of the intertidal zone are very diverse and rich. Several patterns of distribution of organisms in the intertidal zones are given, but the most obvious is the steady increase in species richness from high tide zone to the low tide zone (Webber and Thurman, 1984; Ahmad *et al*. 2011).

The ecology and zonal distribution of animals and plants on intertidal rocky shores has been widely studied in many parts of the world (Underwood, 2000). An important feature of this system is that different species occur in some zones on the shore, but not at others (Menconi *et al*., 1999). The distinct zonation of organisms were reported to be controlled by various environmental factors that affect marine organisms (Nybbaken, 1982; Ahmad *et al*., 2011). The zonation of organism along altitudinal, latitudinal or intertidal gradients is a reflection of their response to both physical and biological factors (Mettam, 1994). Biomass estimation, community composition (Ahmed and Hameed, 1999 a & b; Hameed *et al*., 2001), quantitative and multivariate analysis of the biota and intertidal zonation and distribution of different groups of macrofauna has been fairly well

studied by Pakistani workers (Khan and Dastagir, 1970; Ahmed and Mustaquim, 1974; Ahmed, 1977; Haq *et al*., 1978; Tirmizi *et al*., 1982; Tirmizi and Kazmi, 1986; Burney and Barkati, 1985; Siddiqui and Ahmed, 1992; Afsar *et al.*, 2012; Nazim *et al* 2012) Rehman and Barkati, 2010, 2012). After the review of the literature, it reveals that there is no published information about the community composition and distribution of organisms at the Manora rocky shore except biomass estimation of invertebrate fauna (Nasreen *et al.,* 2000) and describing the diversity of marine animals affected by pollution (Ahmed, 1977). The ecological study of the organisms has been, in many ways, a source of a major contribution to concepts that have moved out into other areas of ecology. The present study provides recent informations of the community distribution and also a guideline for future detailed study about the community composition and zonal distribution of invertebrate fauna and an up-date for area's ecology because this region is rich in species diversity with a variety of marine organisms. Regarding to this, the general survey was organized to observe the abundance and diversity by comparing three tidal zones (High tide zone, Mid tide zone and low tide zone) from the Manora channel.

MATERIALS AND METHOD

Study site:

The Pakistan coastline extends 1046 kilometers (Ashraf *et al* 2004). Manora Islands or Manora is a small peninsula (2.5 km²) located at a latitude 24.8445° N and longitude 66.9199 ° E, just south of the Port of Karachi city, Pakistan. Manora is connected to the mainland by a 12 kilometer long causeway called the Sandspit. On the coast of Karachi, the Lyari River adds small quantities of fresh, but polluted water to Karachi Harbour (Manora Channel) throughout the year. The Manora has both sandy as well as rocky shores. This study was carried out on the exposed rocky belt of the Karachi coast, Manora Island.

Field sampling and methodology:

The collection was carried out in a survey of three months in the year 2014 (pre monsoon) and samples were collected through line transect quadrate method at three different tidal zones; High tide (HTZ), mid tide (MTZ) and low tide (LTZ). Three transects were made into an intertidal rocky belt from the low tide mark to the high tide mark. On each transect, a 0.5 m square frame (0.25 m^2) was placed (30 feet apart) at three tidal zones. Three tide pools were also selected for collection purposes one from each tide zone with the 30 feet distance from each tide pool. Fauna present in the quadrate and in tide pools were collected by simple hand pick, forceps and hand nets. The collected fauna were bagged in labelled polythene bags and kept in plastic bottles that was brought to the laboratory and preserved in 10% formalin for further analyses.

In the laboratory, the organisms were sorted, grouped and identified up to the possible level of identification through the available identification keys: Subrahamanyam *et al*. (1952), Khan and Dastagir (1970 and 1971), Tirmizi and Zehra (1982), Tirmizi and Zehra (1984), Tirmizi and Siddiqui (1981), Tirmizi *et al*. (1982) and Tirmizi and Kazmi (1986).

The cumulative percent abundance of the three surveys of each fauna group and for every species for each zone were estimated. The diversity of all invertebrate macrofauna

for each tide zone was calculated following the Shannon– Wiener index (Shannon and Weaver, 1949).

RESULTS AND DISCUSSION

Percent composition of macrofauna:

The present study is based on the relative abundance, diversity and equitability of organisms found along the coast of Manora Island. The overall fauna composition revealed that the representatives of six (Porifera, Cnidaria, Annelida, Arthropoda, Echinodermata and Mollusca) phyla were identified in the samples. The organism, community composition at Manora ledge was dominated by 75% (39 species) of Mollusca followed by Arthropoda 20% (16 species) and another 4 phyla occupied total 5.25% dominance (Fig. 1).

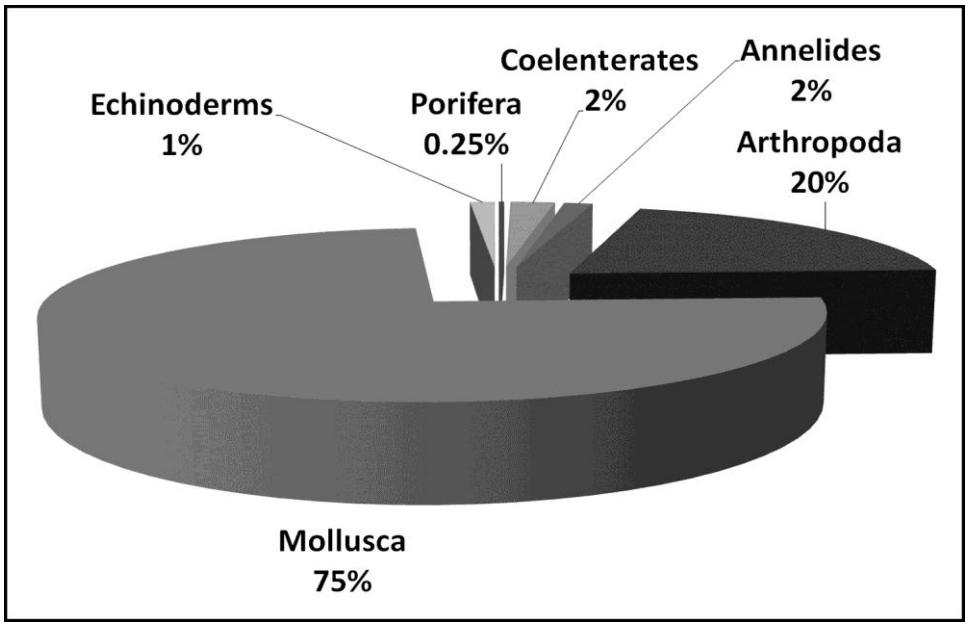

Fig. 1. Abundance based percent composition of different phyla identified during the study.

The fauna composition also varied with the tide zones. At the high tide zone, molluscs were led by 85% followed by mean of arthropods 15% and echinoderms 1%. The mid tide zone was also dominated by molluscs (45%), arthropods (15%), annelids (45%) and echinoderms (2%). The low tide zone was observed a high diversified fauna composition and acquired six phylum representatives. Molluscs were also dominated over here, followed by arthropods, coelenterates, echinoderms, annelids and porifera (Fig. 2).

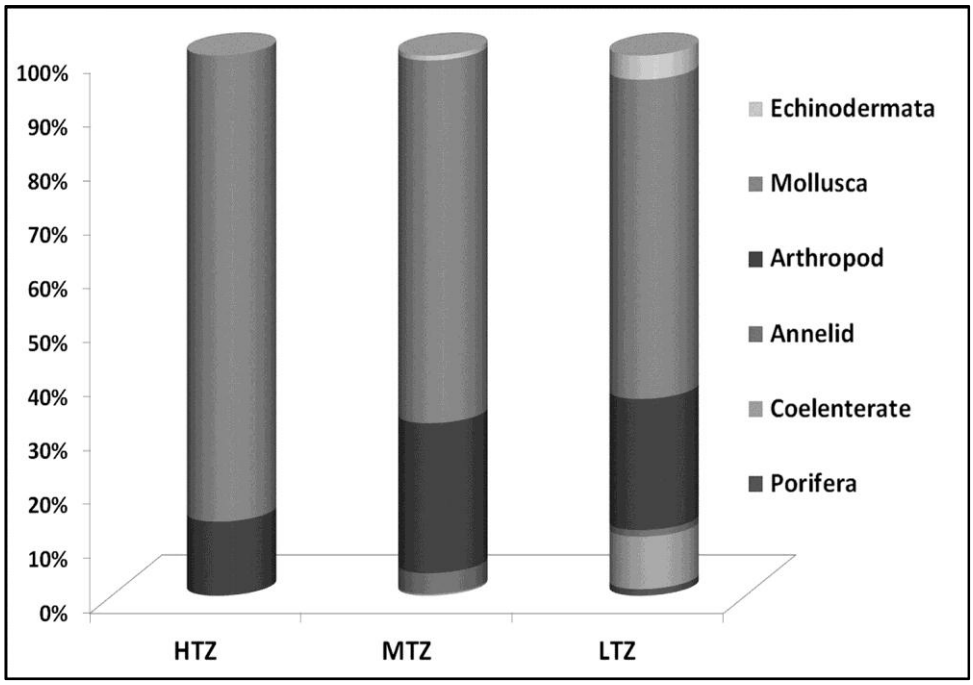

Fig. 2. Percent fauna composition of different phyla at three tide zones of Manora rocky shore.

Community composition of fauna:

A total of 1318 animals were collected, Molluscs and Arthropods contributed nearly 96 percent of total fauna. Molluscs were commonly abundant on this site represented by 3 classes mainly Gastropoda (33 species), Bivalvia (9 species) and Polyplacophora (1 species). The mollusc species like *Cerithium caronarium, Cerithium robus, Conus billiosus, Drupa tuberculata, Monodonta* sp., *Nassarius* sp., *Nerita* sp., *Natica onca, Planaxis sulcatus, Rhinoclavis* sp., *Turbo coronatus, Arca* sp., *Cardium* sp., *Crassostrea tuberculata, Lithophaga lithophaga* and *Perna virdis* were in abundance within the fauna (Table 1). Arthropods were the second most abundant group with 16 species. The crabs of two genera *Charybdis* and *Portunas* species were in abundance as compared to other remaining species. Sponges represent the phylum porifera at this area and present only low tide zone having total abundance 0.412. Jellyfish and sea anemones were presenters of phylum coelenterate and occupied the 2% of total phylum composition at the site. Annelid worms were identified as *Neries* sp. and *Sabella* sp. collected from low and mid tide zones and had abundance 1.507% and 0.14%. Four species of phylum Echinodermata were identified, named as *Asterina button, Ophioneries* sp., *Ohiopeza* sp. and *Cucumaria* sp. It was generally observed that the average number of fauna species increased with the decrease of tidal heights at the site.

Table I. A list of the invertebrate Macrofauna species with percent abundance at three tide zone (LTZ, MTZ and HTZ) collected from Manora rocky shore, 2014.

Phylum	Species	HTZ	MTZ	LTZ	Total percent abundance
Porifera	*Sponges*	0	0	1.214	0.412
Coelenterate	*Jelly fish*	0	0	8.512	2.814
	Sea anemone	0	0.291	1.204	0.514
Annelida	*Neries* sp.	0	3.891	0.826	1.507
	Sabella sp.	0	0	0.412	0.14
Arthropoda	Barnacles-*Balanus amphitrite*	6.391	8.08	10.52	12.23
	Charybdis hellerii	1.512	1.739	0	1.2
	C. hoplites	0	2.691	2.019	1.57
	Eriphia sebana	0	0	0.809	0.29
	Eriphia granulosa	0.372	2.629	2.014	1.609
	Leptodius exaratus	1.351	0	0	0.48
	Thalamita crenata	0.372	0	0.809	0.39
	Portunas pelagicus	0.941	4.129	2.014	2.381
	P. sanguinolentus	0.751	5.608	1.601	2.681
	Parasesarma sp.	1.127	0	0	0.371
	Petrolisthes sp.	0	0	0.41	0.145
	Petrolisthes boscii	0	0.299	1.214	0.504
	Sesarma quadratum	0.56	0	0	0.187
	Grapsus sp.	0	0	1.215	0.408

Continued…..

	Alpheus sp.	0.379	1.989	1.619	1.269
	Diogenes sp.	0561	0.259	0.812	0.529
Echinodermata	*Asterina burtoni*	0	0	1.619	0.539
	Ophioneries sp.	0	0.598	1.215	0.605
	Ophiopeza sp.	0	0.299	0.809	0.369
	Cucumaria sp.	0	0	0.809	0.269
Mollusca					
Gastropoda	*Babylonia spirata.*	0	0.598	0	0.199
	Bursa subgranosa	0	0	0.809	0.269
	Cantharus sp.	0	0.299	0	0.099
	Cellana radiata	0.187	0.299	0.404	0.297
	Batillaria sordida	0	6.586	0	2.195
	Cerithium echinatum	24.06	6.886	0	10.015
	Cerithidea cingulata	5.263	0	0	1.754
	Clanculus sp.	0	1.497	4.048	1.848
	Clypeomorus sp.	2.443	0.299	0	0.914
	Conus billiosus	0.375	2.095	4.048	2.173
	Cypraea sp.	0	0	1.215	0.404
	Drupa tuberculata	1.315	1.197	6.477	2.197
	Epitonium sp.	0	0	2.429	0.809
	Euchelus sp.	0	0	0.809	0.269
	Littorina sp.	0.287	0.299	1.619	0.702

Continued…..

	Mitra ambigua	0	0	0.405	0.135
	Modulus sp.	0.287	1.796	0.404	0.796
	Monodonta sp.	1.903	5.089	1.214	2.602
	Morula granulata	2.443	0.898	1.214	1.518
	Nassarius sp.	0	0.898	0	0.299
	Nerita sp.	11.842	5.988	4.048	7.292
	Natica onca	0	1.796	2.834	1.143
	Ocinebra bombayana	0	0	0.404	0.134
	Onchidium daemelli	0	2.994	0.404	1.132
	Planaxis sulcatus	1.691	4.79	0	2.16
	Pyrene misera	0.916	1.21	0	0.452
	Pyrene sp.	1.503	0.898	0	0.506
	Rhinoclavis sp.	11.654	1.196	2.429	5.293
	Thais sp.	1.851	0	2.834	1.195
	Thais bufo	0.201	0.691	0	0.295
	Trochus sp.	0	0.898	0	0.299
	Turbo coronatus	4.975	7.083	4.858	6.007
	Turbo intercostalis	0.175	1.285	0	0.865
Bivalvia	*Anadara* sp.	0.187	0	0.404	0.197
	Arca sp.	3.517	0	2.024	1.865
	Cardium sp.	0	0	0.404	0.134
	Cassostrea tuberculata	1.879	2.995	4.048	2.674
	Gafrarium sp.	0	0	0.899	0.269

Continued…..

	Lithophaga lithophaga.	1.939	3.912	2.834	2.455
	Mercenaria sp.	0	0.399	0	0.099
	Perna virdis	4.212	0.299	4.815	2.229
	Sunnetta sp.	0.351	0.491	0	0.565
Polyplacophora	*Chiton* sp.	0.375	0.998	0.496	0.694

Zonal diversity

The diversity index (H') of organisms was also calculated and was varied between the tidal zones. It was observed higher at low tide zone (H'=1.429) follow by the mid tide zone (H'= 1.396) and high tide zone (H'=1.196). Molluscs were observed dominated over this site, showed higher diversity at mid tide zone (H'=1.329) followed by high tide zone (H'=1.1864) and low tide zone (H'=0.9294) (Fig. 3).

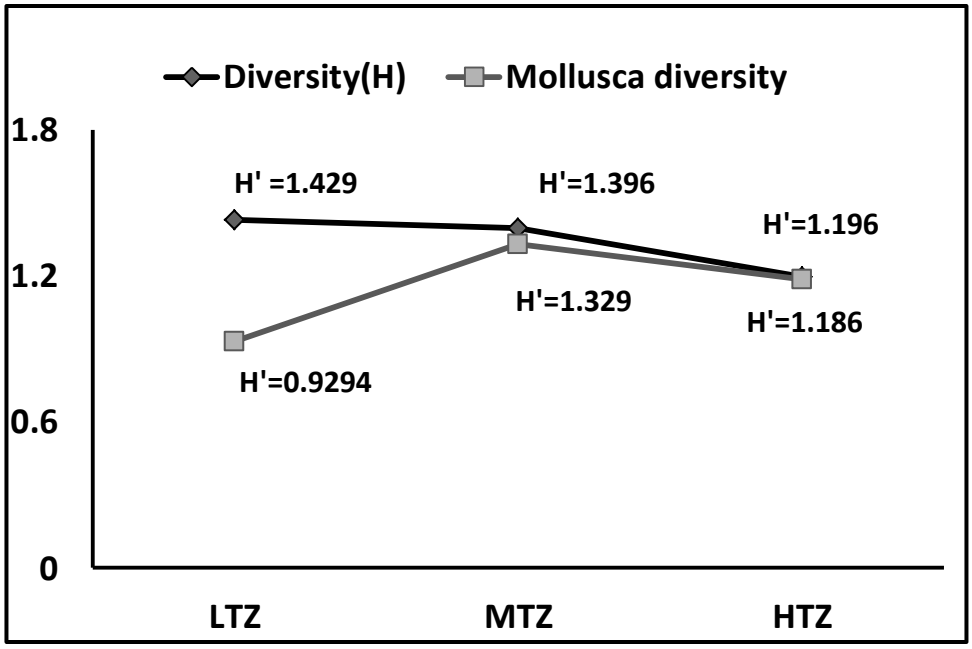

Fig. 3. The diversity indices of total macrofauna and mollusc species distributed at three tidal zone (LTZ, MTZ and HTZ) of the Manora rocky shore.

Rocky intertidal area of Manora harbours a variety of animals belonging to different groups. The rich faunal diversity indicated that the organisms are well adapted to their environmental change and their habitat as well. A total of (68) species of invertebrate organisms was recorded, from which (43) species were belonging to phylum Mollusca

and (16) species were crustaceans remaining were combined of the rest of phyla described. Ahmed (1977) stated that the rocky shores of Karachi are dominated by the mollusc and crustaceans. The phylum Mollusca is a large assemblage of animals having diverse shapes, sizes, habits and occupies different habitats (Subba Rao and Surya Rao, 1993). Molluscs were reported to comprise up to 60% of total biodiversity (Gosliner *et al*., 1996). Molluscan fauna of the rocky shores dominates from high to low water mark. Rahman and Barkati (2012) described 63 species of molluscs from the Manora rocky shore during their detailed study, whereas Nasreen *et al*., (2000) reported 53 mollusc (no detailed description) species in the fauna of Manora according to total biomass of all invertebrate species. During the present study 12 species of crabs were identified in the collection. Siddiqui and Ahmed (1991) found 10 residents and 4 visiting crabs from the area. The difference in the number of mollusc and crab species likely due to the difference in collection time as the present results based on three months study, however the distribution and abundance of macroinvertebrates believed to be influenced by environmental factors, seasons, water current, type of substrate and habitat heterogeneity (Ahmed and Hameed, 1999b; El- Komi, 1996; Dye, 1998; Rahman and Barkati, 2012). The distribution, frequency, variations in abundance and biomass, growth, mortality, reproductive periods correlate with contrasting and changing environmental conditions (Bacci and Sella, 1970). Vertical zonation of animals in the intertidal area is a conspicuous feature of all sea shores (Stephenson and Stephenson, 1972). Amongst these molluscs, the gastropods are typically inhabitant of rocky shores at the intertidal zone and as such they are subjected to extreme environmental conditions. The molluscan community structure is effective indicators of overall ecosystem health and species diversity (Rittschof and McClellan-Green, 2005), making them ideal study organisms of conservation and biodiversity study. The change in environmental factors due to the tidal cycle is one of the most extreme of any marine environment.

The distribution of rocky shore organisms were strongly influenced by tides, exposure and wave action. While factors such as desiccation, overheating, freezing and exposure can also pose serious problems to marine organisms. The intertidal zone also is often a refuge from competitive biological interactions and predation (Beyst *et al*., 2002). The overall diversity of organisms was increased from high tide zone to low tide zone, but the diversity of mollusc species was highest at mid tide zone. The intertidal animals experience extreme physiological stress during the low tide period and those species inhabiting the upper intertidal zone are often more tolerant of thermal and desiccation stress than those found in low tide zones (Sokolova *et al*., 2000). The distribution of organisms indicate non homogenous environment. The barnacles, chitons, a few crabs, limpets and other gastropod species were observed as the predominant organisms in the high tide zone during the present study. In the present study the lower intertidal zone is richer in fauna diversity than the middle and high intertidal zone. This is likely due to the fact that diversity and the spatial distribution of organisms provides information on both organism-organism and organism-habitat relationships (Underwood and Chapman, 1996). The identification of spatial distribution pattern of intertidal organisms provides baseline data which helps in the understanding of the processes affecting rocky shore communities (Underwood and Chapman, 1996).

The lower intertidal zones are reported to be rich in biodiversity because most of the times the organisms remain submerged in water. Macroalgae in most of the hard bottom

intertidal regions provides a major structure that can serve as habitat for associated invertebrates (Hayward, 1980). Macroalgae also provides shelter, protection and food to associated organisms (Duffy and Hay, 1991; Iken, 1999; Molina-Montenegro, 2005).

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